PicoLAS

FOCUSSING POWER TO THE POINT

User Manual

Rev. 12.06

LDP-QCW 300-12

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How to use the Manual

⚠ Remark: The LDP-QCW described in this manual is a base-plate cooled laser diode driver. Improper cooling may cause an internal over temperature shutdown. The two fans in one side of the unit have to prevent local thermal hot spots inside the unit. They can not compensate improper base plate cooling. The air inside an enclosure within an OEM application is usually enough to yield enough air flow. Please do not cover any ventilation slots.

Base plate cooling: Depending on the final application and operation regime, this unit may stay none-cooled or must be assembled onto a heat sink.

Please refer to chapter Power dissipation for more details about the thermal power losses during operation.

You me use a passively or an actively air/water cooled device.

Housing: All units are delivered with housing. Changes are possible; the units can be delivered without housing upon request.

Before powering on your unit, read this manual thoroughly and make sure your understood it fully.

⚠ Please pay attention to all safety warnings.

If you have any doubt or suggestion, please do not hesitate to contact us!

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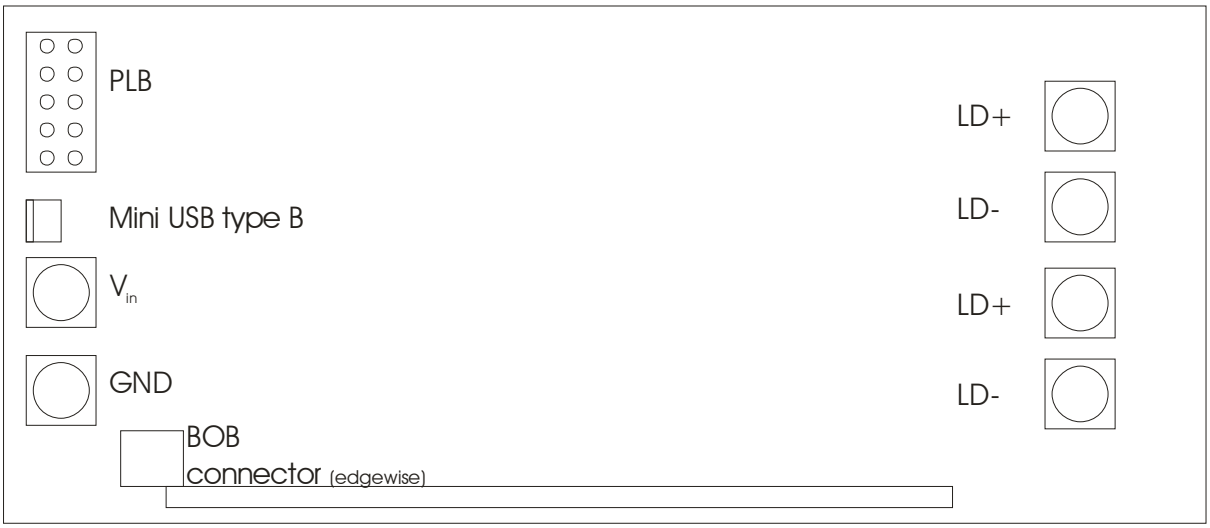
How to get started *(refer to drawings on next 2 pages)*

Step #	What to do	Check
1	Unpack your device and place it in front of you as shown on the next page.	
2	Connect a load (for example your laser diode) to the output.	⚠ Make sure to use both anode and cathode connectors in parallel.
3	Connect the PLB-21 or the USB cable	A driver is required in order to use the LDP-QCW with a PC. See chapter "Controlling the LDP-QCW via USB" for more information
4	Connect the input power supply; make sure that polarity is correct. The supply voltage must be at least 24 V and about 5 V above the desired capacitor bank voltage.	⚠ Make sure that your power supply does not have any voltage overshoots when switching on or off. Do not exceed the maximum operating voltage of 48 V
5	Switch the power supply on	
6	If a PLB-21 is used, its display may show a message about downloading a new driver. Confirm this with YES.	See chapter "Controlling the LDP-QCW using a PLB-21" for more information
7	Set all required parameters using the PLB-21 or USB interface	See chapter "Controlling the LDP-QCW using a PLB-21" for more information
8	Apply +5V to the MasterEnable pin of the BOB connector	See chapter "Interface specifications" for more information
9	Apply +5V to the Enable pin of the BOB connector. This will enable the output	See chapter "Interface specifications" for more information
10	Monitor the current pulses using an oscilloscope connected to the current monitor output	See chapter "Interface specifications" for more information
11	Verify that the PULSER_OK signal is +5V	See chapter "Interface specifications" for more information

Description of available Connectors

The following drawing shows all connections which are available to the user.



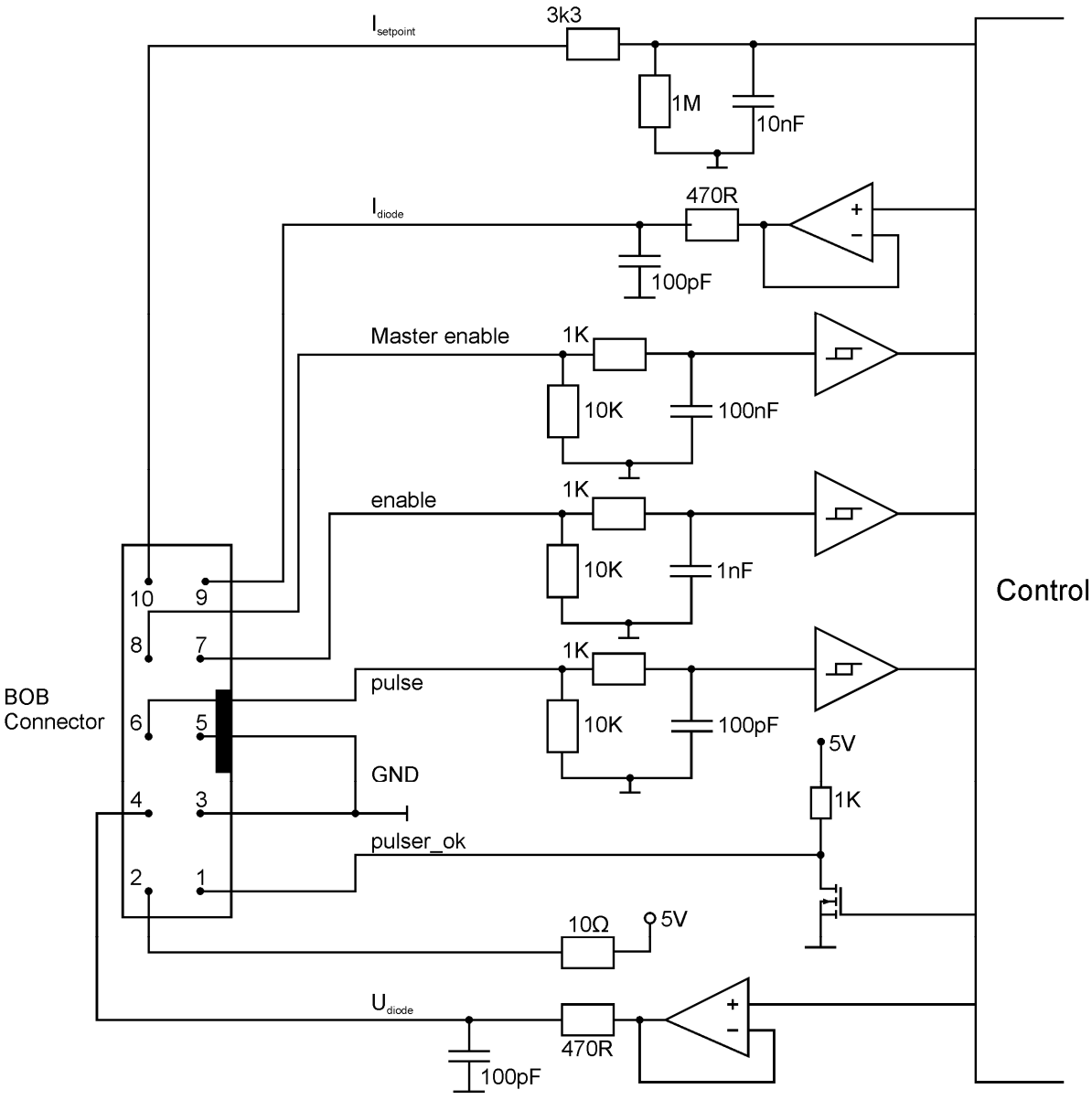
LDP-C BOB Connector	See section interface specifications for detailed information. (Break-out-board connector.)
PLB	Connector for PLB-21 (protected against polarity reversal)
V_{in}	Supply voltage
GND	Supply ground
LD+	Positive laser diode output (anode). Use both connectors parallel for high currents.
LD-	Negative laser diode output (cathode). Do not connect to ground! Use both connectors parallel for high currents.
Mini USB	Mini USB connector for connecting the driver with a computer.

For a more convenient use of the driver (e.g. in laboratory use) we recommend the optional available product accessory LDP-C-BOB. Please see LDP-C-BOB manual for further details.

Interface Specifications

The following figure shows the input and output signals of the external analogue BOB connector.

The BOB (Break-out Board) is recommended for easy testing of the driver. It will be replaced in the application by your machine interface.



Functional Description of BOB-Connector Interface

Pin Description (numerical assorted)

Pin1: Pulser OK
The state of this Signal indicates weather the driver is ready (5V) or it has an error pending (0V).

Pin 2: 5V
This pin provides 5 Volts for external usage. Please note that the load should not exceed 10mA, otherwise the voltage will drop.

Pin 3: GND
This pin is connected to ground.

Pin 4: U_{diode}
This signal provides near real-time measurement of the laser diodes compliance voltage. The scaling is 10 volts per volt measured into 1MOhm.

Pin 5: GND
This pin is connected to ground.

Pin 6: Pulse
This signal is used in the external end external controlled trigger mode. Connect your external trigger source to this pin. The signal amplitude should be within 3 to 6Volts.

Pin 7: Enable
This signal is used to enable / disable the current output of the driver during operation.
It must be pulled low to reset an error condition or to re-enable the driver after Master Enable was pulled low.

Pin 8: Master Enable
This signal is used as an interlock safety feature that disables the complete driver if set to 0V during operation. In order to re-enable the driver after this emergency shutdown the enable signal must first set to 0V.
If this feature is not required this pin can be connected to Pin 2 (5V).

Pin 9: I_{diode}
This signal provides near real-time measurement of the laser diodes current flow. The scaling is 200 amperes per volt measured into 1MOhm.

Pin 10: $I_{setpoint}$
This signal is used to provide an external current set point. The voltage at this pin is periodically sampled by the driver if it is configured to use the external set point current

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Dos and Don'ts

Never ground any output connector.
Never use any grounded probes at the output.
Do not connect your oscilloscope to the output!
This will immediately destroy the driver and the probe!
For measuring current and voltage you connect the scope to Pin 9 or Pin 4 of the BOB connector respectively.

Keep connecting cables between power supply and driver as well as the connection between driver and laser diode as short as possible.

Mount the driver on an appropriate heat sink!

Please be aware that there might be hot surfaces, be careful not to touch them!

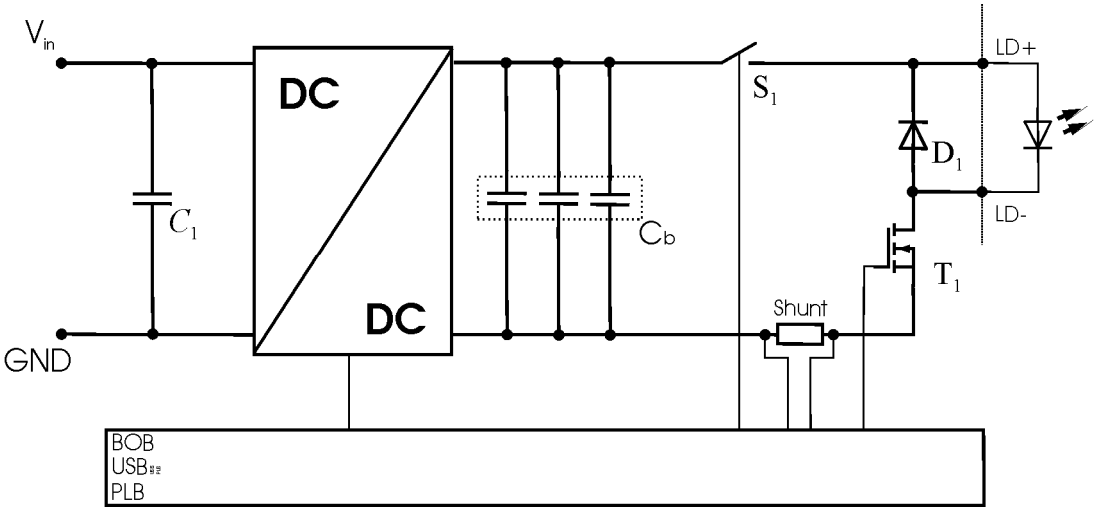
Do never connect the oscilloscope to the output connectors!!!!
(Please Note: above picture shows another but similar PicoLAS driver)

Functional Description

The driver uses a DC-DC converter to load a capacitor bank to a defined voltage. A PI regulator uses T_1 and a shunt to control the current flow through the laser diode.

Laser diode current and compliance voltage are pre-processed and fed to the external BOB-connector.

Several security features protect the laser diode and driver from damage. D_1 protects the laser diode from reverse currents. The switch S_1 is automatically opened when an over current as well as an internal failure (such as over temperature, etc.) is detected.



Operation Principle of LDP-QCW driver

Element	Function
C1	Input Buffer Capacitor
Cb	Capacitor bank
S1	Security Switch
D1	Laser diode protection diode
T1	Current regulation MosFET
Shunt	LD-current monitor

Trigger modes

The LDP-QCW supports tree different trigger modes as explained below

Internal

The pulse generation is performed by an internal pulse generator. The pulse width and repetition rate is user configurable via the PLB-21 or the serial interface.

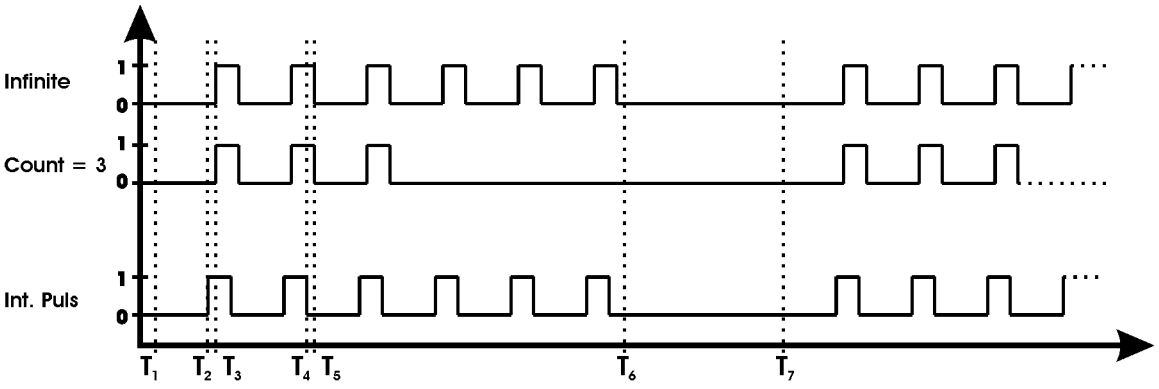
In addition, the number of pulses to be generated can be configured. To use this feature the

wie soll das gehen?

user has to set the TRG_COUNT bit in the LSTAT register to "1". The current output is automatically disabled after an internal counter reaches the configured value. The counter is reset by setting the L_ON bit of the LSTAT register to "0" or by setting the ENABLE pin to 0V.

Please note that the maximum pulse width depends on the current repetition rate as well as the maximum repetition rate on the current pulse width.

The following diagram shows an example of generated pulses. The lower graph shows the internal pulse generator, the upper two graphs the trigger pulses generated out of it.

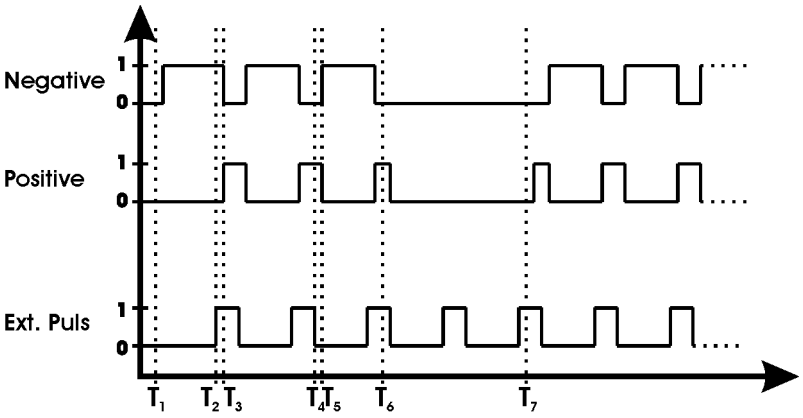


	meaning
T_1	enabling of the output
T_1-T_2	The delay between output enable and the first generated pulse depends on the configured repetition rate. It nearly equals the pulse pause time.
T_2-T_3	Pulse rise time. It depends on the load inductance.
T_4-T_5	Pulse fall time. It depends on the load inductance.
T_6	disabling of the output
T_7	re-enabling of the output

External

The pulse generation is performed by an external pulse generator connected to the pulse input on the BOB connector. The pulses can be inverted by setting the TRG_EDGE bit in the LSTAT register to "0".

The following diagram shows an example of generated pulses. The lower graph shows the external pulse input, the upper two graphs the trigger pulses generated out of it.

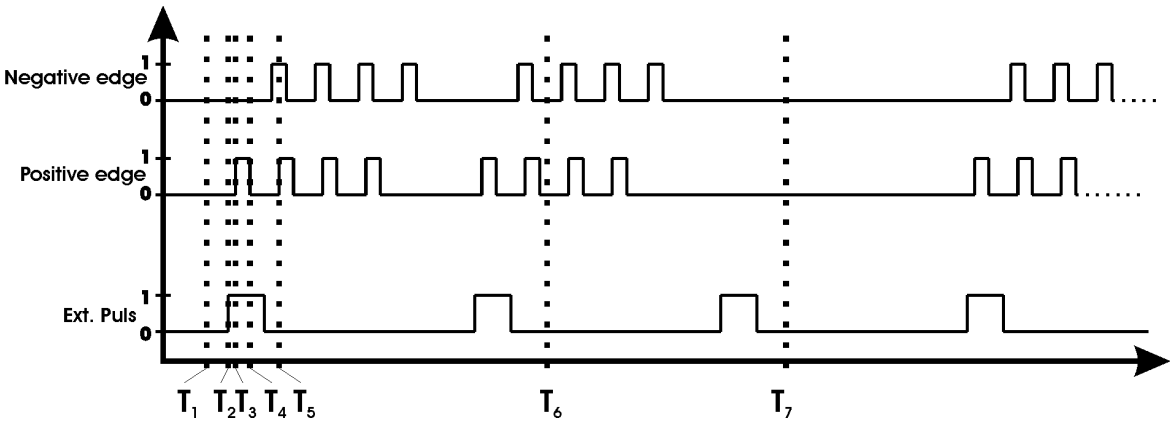


	meaning
T_1	enabling of the output
T_2-T_3	Pulse rise time. It depends on the load inductance.
T_4-T_5	Pulse fall time. It depends on the load inductance.
T_6	disabling of the output
T_7	re-enabling of the output

External controlled (ext. ctrl.)

This trigger mode uses the external trigger input to control the internal pulse generator. It is used to generate a number of pulses per rising of falling edge of the external trigger input. Setting the TRG_EDGE bit in the LSTAT register to "1" uses the rising edge, setting it to "0" uses the falling edge.

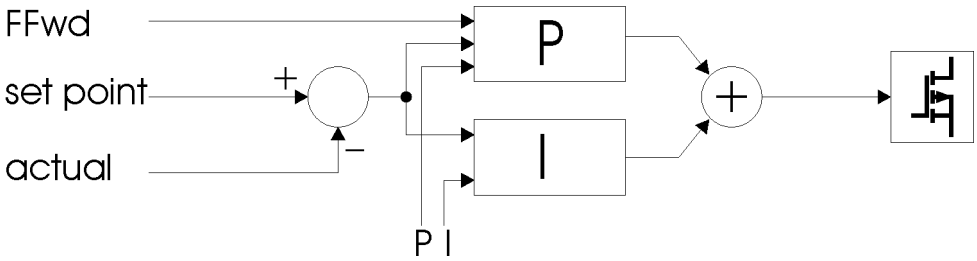
The following diagram shows an example of generated pulses. The lower graph shows the external pulse input, the upper two graphs the trigger pulses generated out of it.



	meaning
T_1	enabling of the output
T_2-T_3	Pulse rise time. It depends on the load inductance.
T_4-T_5	Pulse fall time. It depends on the load inductance.
T_6	disabling of the output
T_7	re-enabling of the output

Regulator

The LDP-QCW implements a proportional – integral (PI) regulator to control the current flow through the connected load. The following diagram shows a simplified layout:



Depending of the chosen operating mode the user has the possibility to modify all relevant parameters to a specific need. This is done through the digital interface (PLB-21 or USB).

The "P" value defines the strength of the proportional part of the current regulator. This values ranges from 0 to 4095. During normal operation this part is not used and can be set to zero. If this value is too high it may lead to a current overshoot.

The "I" value defines the strength of the integral part of the current regulator. This value ranges from 0 to 4095. A recommended value for normal operation is 30 … 60. If this value is too high it may lead to a current overshoot.

PicoLAS implemented an active nonlinearity compensation of the output stage. This speeds up the device, prevents excessive current overshoots and yields a better accuracy with high impedance loads. The influence of this part of the regulator can be user defined and is called FFwd.
However, the interconnection between the voltage and the current flow on the output is calibrated during fabrication. This is used in operating mode 1. So it is not necessary to change this value at all. If needed, it can be adjusted between the values 0 to 7.5 by the customer.

Be careful if changes are performed with the FFwd-value. The effect is high and may cause damage if not adjusted properly. Wrong settings are not covered by warranty.

Mode 0: manual

In this operation mode all parameters can be modified.

This mode is recommended only for experienced users as any wrong setting may lead to a current overshoot at the output.

Mode 1: semi-auto

In this operation mode the feed forward value is automatically chosen in dependence of the current setpoint. This is recommended for normal operation as it guarantees no current overshoot at the output.
The P and I values can be freely chosen, but the default values are sufficient for most applications.

VCap

The VCap value defines the voltage of the capacitor bank (see chapter functional description). This value is a bit tricky to determine as it depends on the chosen pulse width, repetition rate and compliance voltage.
If his value is too low the current will drop during the pulse or not even reach the set point, if it is too high the output stage will heat up fast and lead to an over temperature shutdown.

The following equation can be used to calculate the capacitor voltage in dependence of the output current, compliance voltage and pulse width:

$$V_{cap} = 5 + U_{LD} + (I_{LD}(0.011 + \frac{T_{pulse}}{0.112}))$$

where

U_{LD} = compliance voltage
I_{LD} = current setpoint
T_{pulse} = pulse width

This equation does not use the repetition rate. Hence this value must be increased if a current drop is measured during operation.

For first tests or low pulse width and repetition rate it can safely be set to maximum, but the higher this value the greater the power losses are in the output stage.

LED codes

The LDP-QCW is equipped with a red and a green status LED.
The red LED is connected to the Pulser_ok pin of the BOB connector and will lit if the signal goes low.
The green LED the following codes:

Permanent on:	The LDP-QCW operates normally and the current output is enabled
Blink 1x:	Master Enable is given, but Enable not
Blink 2x:	Master Enable is not given

Power Supply

To obtain a good pulsing performance with the driver, it requires an appropriate power supply unit (PSU). The PSU has to supply not only the power that is delivered to the laser diode but also the power to compensate for the losses in the driver itself.

As the valid supply voltage ranges from 24V to 48V, it depends on the configured voltage of the capacitor bank. The internal DC-DC converter needed at least 5 Volts above the desired capacitor bank voltage (VCap).

Cooling

The maximum thermal dissipation of the LDP-QCW depends on the configured pulse length, repetition rate and capacitor bank voltage.

Test Load

A common method to test the driver is to connect a regular silicon rectifier diode to the driver output. Here has to be paid attention to the junction capacitance of the diode. Only fast recovery diodes (or similar) have a low parasitic capacitance as laser diodes. To achieve reasonable test results, the parasitic elements of the test diode and the connection must be very similar to a laser diode approach. Regular silicon rectifier diodes have a junction capacitance of several microfarads and are not a suitable test load! The use of these diodes will yield in incorrect current measurement at the pulse edges!

It is also possible to test the driver using a shortcut. This will not damage it, but result in an incorrect measurement for the rise and fall time of the current pulse.

Over Temperature Shutdown

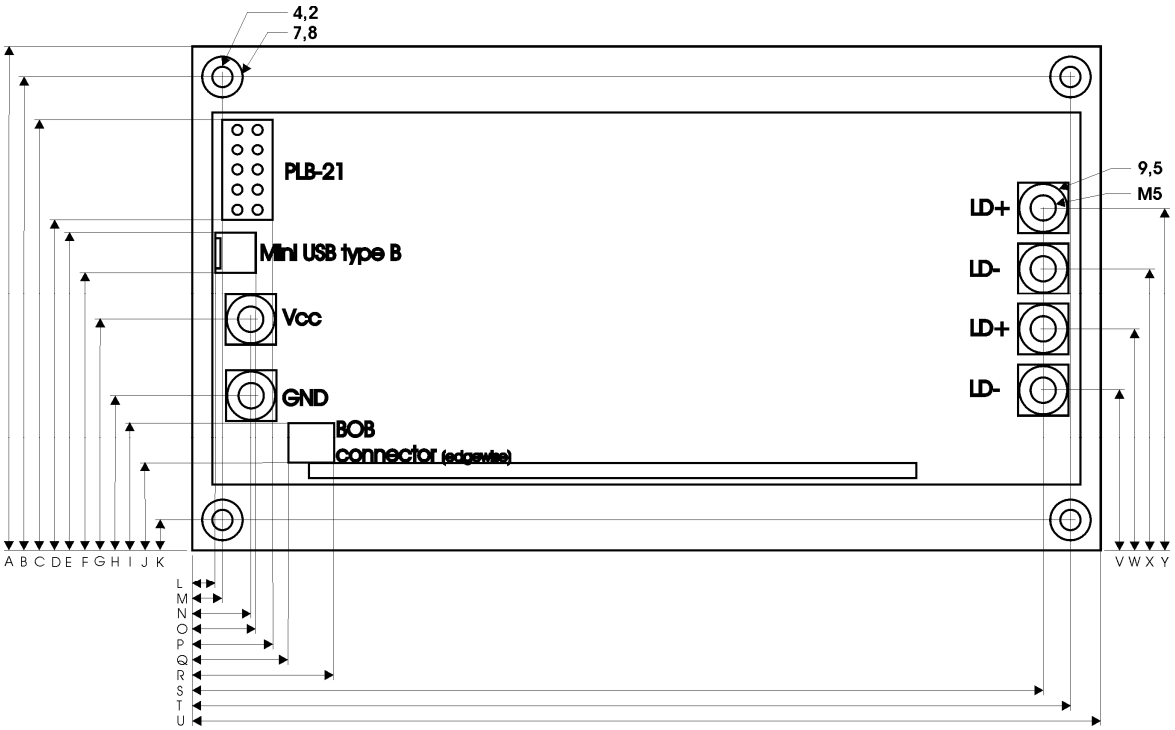
To protect the Laser Diode and the driver itself, the LDP-QCW automatically disables itself if its temperature rises above the maximum allowed operating temperature. This condition is latched and the LDP-QCW will not start working until temperature drops five degrees and the ENABLE-pin is toggled. During the over temperature shutdown, the Pulser_ok output (Pin 1 of the BOB-Connector) is pulled low.

Absolute Maximum Ratings

Output current	50 … 300A
Max. compliance voltage	12V (short-circuit proof)
Min. pulse duration	< 100us
Max. pulse duration	5 ms
Max. repetition rate	> 1 KHz
Max. duty cycle	10%
Max. rise time	< 10us
Current overshoot	< 5% (depending on regulator settings)
Pulse trigger input	5V TTL
external current setting input	200 A/V
Current monitor	200 A/V
Connectivity	LDP-C BOB PLB-21 USB 2.0
Supply voltage	24 … 48V (min. 5V above VCap)
Max. power dissipation	TBD
Dimensions in mm	100 x 180 x 100
Weight	1.2 Kg
Operating temperature	0 to +55°C

Mechanical Dimensions

The following dimensions are in millimetres (mm).



A	100
B	94
C	85,71
D	65,39
E	62,82
F	55,26
G	45,7
H	32,37
I	26
J	17
K	6
L	6

M	6
N	4,5
O	13,5
P	15,8
Q	19
R	27
S	169
T	174
U	180
V	31,73
W	43,8
X	55,86
Y	67,93

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Controlling the LDP-QCW using a PLB-21

To control the LDP-QCW with a PLB-21 it must be connected via the enclosed cable.

The PLB-21 will not work if USB and PLB-21 are connected at the same time.

When the PLB-21 is connected the first time to a LDP-QCW you are asked to download a new driver. This must be confirmed with "yes" for working the PLB-21 properly.

Menu Structure

The following diagram shows the structure of the PLB-21 menu which affects the LDP-QCW. All entries are described in detail. All other menu entries are described in the PLB-21 manual. For detailed instructions see the PLB-21 manual.

Menu root

- Pulseparameter
  - Width
  - Reprate
  - Cur(int/ext)
- Config
  - Mode
  - Cur. stp.
  - OverCur
- Trigger
  - Input
  - Edge
  - Count
- Defaults
  - Autoload
  - Save
  - Load
- Temperature
  - Off
  - Temp1
  - Temp2
  - Temp3
  - Temp4
- Regler
  - I-Delay
  - I
  - FFwd
  - Voltage
- Regler2
  - P

Pulseparameter

Width
This value defines the pulse width of the internal trigger generator. When the value reads external the internal generator is not used.

Reprate
This value defines the repetition rate of the internal trigger generator. When the value reads external the internal generator is not used.

Cur (int/ext)
This value defines the setpoint current.
When using the internal setpoint, the value can be modified by the user.
When using the external setpoint, the value shown is measured value supplied at Pin 10 of the BOB connector. The display is updated every few seconds, so it is not accurate when using analogue modulation.

Config

Mode
In this menu point the operation mode of the LDP-QCW can be selected. See chapter "current regulator" for more information.

Cur. stp.
The LDP-QCW can be configured to use the internal or external setpoint current. If switched to external, an appropriate voltage must be applied to the BOB connector.

OverCur
If enabled, the LDP-QCW disables automatically if the current flow reaches the given value.

Temperature
The LDP-QCW is equipped with several temperature sensors. In this submenu, the actual and shutdown temperatures can be read and modified. All values are in °C.

Dev. Off
This shows the shutdown temperature. If the LDP-QCW reaches this temperature during operation, the output will be disabled and an error message is displayed.

Temp 1…4
This shows the actual temperatures measured by the sensors of the LDP-QCW.

Trigger

Input
This setting defines which trigger input / mode is used. Please see chapter trigger for more information.

Edge
This setting defines which edge / polarity is used for the trigger. It is not available in every trigger mode. Please see chapter trigger for more information.

Count
This setting defines the number of pulses generated per trigger event. It is not available in every trigger mode. Please see chapter trigger for more information.

Defaults

def. pwron
If enabled the LDP-QCW loads default values every time it is powered on. These values are CRC checked at power-up. If this check fails the values are not loaded and an error message is displayed.

Save defaults
When the Jogdail is turned or the ENTER key is pressed all current values are saved.

Load defaults
When the Jogdail is turned or the ENTER key is pressed all current values are overwritten by the saved ones. If the output was enabled at this time it becomes disabled.

Regler

I-Delay
This value represents the switching-point of the integral part of the current regulator. It is defined in percent of the setpoint current. See chapter current regulator for more information.

I
This value defines the strength of the integral part of the current regulator. The value ranges from 0 to 4095.

FFwd
This value represents the feed forward voltage of the current regulator. See chapter current regulator for more information.

Voltage
This value represents the precharge voltage of the current regulator. See chapter current regulator for more information.

Regler2

P
This value defines the strength of the proportional part of the current regulator. The value ranges from 0 to 4095.

If an Error Occurs

If an error occurs during operation the pulse output is switched off, the "pulser_ok_ext" signal on the BOB connector is pulled low and a message is displayed on the PLB-21. If no other action is described on the display, a toggle of the ENABLE pin resets the error condition.

Controlling the LDP-QCW via USB

Introduction

In addition to the PLB-21, the LDP-QCW also has a USB interface to communicate with a computer/laptop. This interface allows communications over a serial text interface as well as using the PicoLAS protocol. While the text interface is designed for communication with a terminal program, the PicoLAS protocol is designed as a system interact protocol.

The switching between the two protocols occurs automatically as soon as the LDP-QCW receives a certain sequence. The corresponding commands are:

- **PING** for the PicoLAS protocol
- "**init**" followed by <Enter> for the text interface

Description of the USB Interface

The USB connection of the LDP-QCW emulates a virtual COM port under Windows. The necessary drivers can be downloaded free of charge under http://www.ftdichip.com/Drivers/VCP.htm, or they are already included in the current Linux kernels. The virtual COM port created by this can be addressed like a regular one. The connection settings are:

Baud rate	115200
Data bits	8
Stop bits	1
Parity	even

The Serial Text Interface

The following section describes the structure and commands of the text interface.

Structure

Every command that is sent to the LDP-QCW must be completed with a CR (Enter). It consists of a command word followed by one ore more a parameters. If the command was successfully executed a "00" is sent, otherwise a "01". If there is an error pending, the response will be "10", otherwise "11". If the command requires an answer parameter, this parameter is sent before the confirmation is given.

Example:

The user would like to read out the actual setpoint current:

User input: gcurrent<Enter>

Output of the LDP-CW: 250<CR><LF>

00<CR><LF>

Example 2:

The user would like to set a new setpoint current:

User input: scurrent 270<Enter>

Output of the LDP-CW: 270<CR><LF>

00<CR><LF>

Input is done in ASCII code and is case sensitive. Every terminal can be used that supports this standard.

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Commands for the LDP-QCW

The following table contains a command reference for the LDP-QCW.

Command	Parameter	Description
ghwver	-	returns the hardware version number
gswver	-	returns the software version number
gserial	-	returns the serial number
gname	-	returns the device name
ps	-	prints out all settings
loaddef	-	load default values
savedef	-	save all settings as default values
enautodef	-	enables the automatic loading of default settings on power on
disautodef	-	disables the automatic loading of default settings on power on
gerrtxt	-	returns the error register in text-form
gerr	-	returns the error register as a 32bin number
glstat	-	returns the laser status register
slstat	32bit number	sets the laser status register to the given value.
gtrgmode	-	returns the actual trigger mode. See below for more information.
strgmode	mode	sets the trigger mode to the given value. See below for more information. The return value is the new mode.
gtrgcount	-	returns "0" if counting is disabled or "1" if enabled.
strgcount	0 or 1	enabled (1) or disables (0) the counting mode
gtrgedge	-	returns "0" for negative edge or "1" for positive edge
strgedge	0 or 1	sets the trigger edge for external trigger."0" = negative, "1" = positive
lon	-	enabled the output (needed after any change in trigger modes)
loff	-	disables the output
curint	-	switches to internal current set point
curext	-	switches to external current set point
gmode	-	returns the current regulator mode. Mode 0: manual Mode 1: semi-automatic See chapter "current regulator" for more information
smode	0 … 2	sets the current regulator mode to the given value. Mode 0: manual Mode 1: semi-automatic See chapter "current regulator" for more information

Command	Parameter	Description
gisoll	-	returns the actual setpoint current in [A]
gisollmin	-	returns the minimum setpoint current
gisollmax	-	returns the maximum setpoint current
sisoll	current in [A]	sets the internal setpoint current to the given value. This value must be within the minimum/maximum borders (See above). The return value is the new setpoint.
gtemp	-	returns the actual device temperature in °C. This is the maximum of the single temperature sensors
gtemp1	-	returns the value of temp. sensor number 1 in [°C]
gtemp2	-	returns the value of temp. sensor number 2 in [°C]
gtemp3	-	returns the value of temp. sensor number 3 in [°C]
gtemp4	-	returns the value of temp. sensor number 4 in [°C]
gtemphys	-	returns the temperature at witch the device switches back on after an over temperature shutdown in [°C]
gtempwarn	-	returns the temperature at witch the TEMP_WARN bit in the ERROR register is set
gtempoff	-	returns the over temperature shutdown value in [°C]
gwidth	-	returns the actual pulse width of the internal pulse generator in [us]
gwidthmin	-	returns the minimum possible pulse width of the internal pulse generator in [us]
gwidthmax	-	returns the maximum possible pulse width of the internal pulse generator in [us]
swidth	width in [us]	sets the pulse width of the internal pulse generator. Please note that any change in this register affects the maximum possible repetition rate. The return value is the new pulse width.
greprate	-	returns the actual repetition rate of the internal pulse generator in [Hz]
grepratemin	-	returns the minimum possible repetition rate of the internal pulse generator in [Hz]
grepratemax	-	returns the maximum possible pulse width of the internal pulse generator in [Hz]
sreprate	repetition rate in [Hz]	sets the repetition rate of the internal pulse generator. Please note that any change in this register affects the maximum possible pulse width. The return value is the new repetition rate.
gcount	-	returns the number of pulses per trigger event. Only valid if counting is enabled. See chapter “Trigger modes” for more information
gcountmin	-	returns the minimum number of pulses generated per trigger event

Command	Parameter	Description
gcountmax	-	returns the minimum number of pulses generated per trigger event
scount	number of pulses	sets the number of pulses generated per trigger event. Only valid when counting mode is enabled. See chapter "Trigger modes" for more information
gffwd	-	returns the actual voltage of the feed-forward part of the current regulator in [V]. See chapter "Current regulator" for more information.
gffwdmin	-	returns the minimum possible value of the feed-forward voltage in [V]
gffwdmax	-	returns the maximum possible value of the feed-forward voltage in [V]
sffwd	voltage in [V]	sets the feed-forward voltage to the given value. Two positions after decimal point are used (e.g. 3.45). It must be within the borders of gffwdmin / gffwdmax.
gocur	-	returns the actual over current shutdown value in [A]. The output will be disabled when the output current reaches this value. Please note that this function must be enabled to use it.
gocurmin	-	returns the minimum possible over current shutdown value in [A]
gocurmax	-	returns the maximum possible over current shutdown value in [A]
socur	current in [A]	sets the over current shutdown value to the given value in [A]. The output will be disabled when the output current reaches this value. Please note that this function must be enabled to use it.
enocur	-	enables the over current protection
disocur	-	disables the over current protection
gi	-	returns the actual strength of the integral part of the current regulator.
gimin	-	returns the minimum strength of the integral part of the current regulator.
gimax	-	returns the maximum strength of the integral part of the current regulator.
si	value	sets the strength of the integral part of the current regulator to the given value.
gp	-	returns the actual strength of the proportional part of the current regulator.
gpmin	-	returns the minimum strength of the proportional part of the current regulator.

gpmax	-	returns the maximum strength of the proportional part of the current regulator.
sp	value	sets the strength of the proportional part of the current regulator to the given value.
gvcap	-	returns the actual pre charge voltage of the internal capacitor bank in [V].
gvcapmin	-	returns the minimum pre charge voltage of the internal capacitor bank in [V]
gvcapmax	-	returns the maximum pre charge voltage of the internal capacitor bank in [V]
svcap	voltage in [V]	sets the pre charge voltage of the internal capacitor bank to the given value in [V]. One position after decimal point is used (e.g. 12.5)
gidelay	-	returns the delay value to witch the output current must rise before the integral part of the current regulator is switched on. This value is measured in percent of the set point current.
gidelaymin	-	returns the minimum i-delay value
gidelaymax	-	returns the maximum i-delay value
sidelay	delay in %	sets the delay value to witch the output current must rise before the integral part of the current regulator is switched on to the given value. This value is measured in percent of the set point current.

If an Error Occurs

If an error occurs during operation the pulse output is switched off and the return value of a command is no longer "00" or "01" but "10" or "11". Errors have to be acknowledged with a toggle of the ENABLE signal, otherwise switching on again of pulse output is not possible.
To retrieve the error, use the **gerror** command for the content of the ERROR register or the **gerrtxt** command for a human readable form.

The PicoLAS Protocol

The following section describes the structure and possible commands of the PicoLAS protocol.

Structure

Each transmission consists of 12 bytes – called a frame as follows – which must be sent consecutively. Otherwise the system times out and the transmission must start again from the beginning.

A frame has a fixed structure. The first two bytes describe the command, the following eight bytes the parameters, followed by one reserved byte and one checksum byte. The checksum is calculated out of the first 11 bytes which are linked by a bitwise XOR.

Thus a frame has the following structure:

Byte	Meaning
1	Bit 8-15 of the command
2	Bit 0-7 of the command
3	Bit 56-63 of the parameter
4	Bit 48-55 of the parameter
5	Bit 40-47 of the parameter
6	Bit 32-39 of the parameter
7	Bit 24-31 of the parameter
8	Bit 16-23 of the parameter
9	Bit 8-15 of the parameter
10	Bit 0-7 of the parameter
11	Reserved, always 0x00
12	Checksum

A properly received frame must be acknowledged by the recipient with an answer, which is also a frame. If the acknowledgement does not occur the command has not been processed and the sending procedure should be repeated.

If the recipient recognizes the command as valid, but not the parameters, then it will answer with an ILGLPARAM (0xFF12) as command.

In case that the recipient receives an invalid command it will answer with UNCOM (0xFF13).

If a faulty checksum is recognized then the answer is RXERROR (0xFF10). If this error occurs often the connection should be checked.

Using the REPEAT (0xFF11) command the recipient can instruct the sender to send the most recent frame again.

General Commands

The following list contains an overview of the general commands which are supported by every product from PicoLAS which makes use of this protocol. The explanation of the individual commands is given further below.

Command Name	Sent Frame		Answer Frame	
	Command	Parameter	Command	Parameter
PING	0xFE01	0	0xFF01	0
IDENT	0xFE02	0	0xFF02	ID
GETHARDVER	0xFE06	0	0xFF06	Version
GETSOFTVER	0xFE07	0	0xFF07	Version
GETSERIAL	0xFE08	0 … 255	0xFF08	Refer to description
GETIDSTRING	0xFE09	0 … 255	0xFF09	Refer to description

PING

This command is used to determine the presence of a connected device and to initialize the interface. It has no effect on the condition of the recipient. The command parameter is always zero, the answer parameter too.

IDENT

It is used to determine the device ID of an attached recipient. Has no effect on the condition of the recipient. The parameter is always 0. The answer contains the ID.

GETHARDVER

This command instructs the recipient to send back the version number of the hardware being used. The parameter is always zero. The answer contains the hardware version of the recipient. The format of the answer is: 0x000000<major><minor><revision>. In other words, one byte for each of the three elements of the version number.
As example, version 1.2.3 has the parameter 0x000000010203.

GETSOFTVER

Instructs the recipient to send back the version number of the software being used. The parameter is always 0.
The answer contains the software version of the recipient. The format of the answer is: 0x000000<major><minor><revision>. In other words, one byte for each of the three elements of the version number.
As example, version 2.3.4 has the parameter 0x000000020304.

GETSERIAL

Instructs the recipient to send back its serial number. If 0 is sent as parameter, the answer contains the number of (ASCII) digits of the serial number; otherwise the respective position of the serial number is sent in ASCII format.

GETIDSTRING

Instructs the recipient to send back the name of the device. If 0 is sent as parameter, the answer contains the number of digits of the string, otherwise the respective position of the serial number is sent in ASCII format.

In addition to these commands there are some answers, which can be given to every command:

Answer	Answer Frame	
	Command	Parameter
RXERROR	0xFF10	0
REPEAT	0xFF11	0
ILGLPARAM	0xFF12	0
UNCOM	0xFF13	0

RXERROR
If a frame is repeated four times and still broken this answer will be send.

REPEAT
The last frame was received in a broken state. The transmission must be repeated. This can be up to four times before a RXERROR will be send.

ILGLPARAM
The parameter of the last frame had an incorrect value.

UNCOM
The command of the last frame is unknown by the device.

Commands for the LDP-QCW

The following table contains a list of the commands which the LDP-QCW supports in addition to the generally applicable commands. An explanation of each individual command follows afterwards.

Command	Sent Frame		Received Frame	
	Command	Parameter	Command	Parameter
GETTEMP	0x1	0	0x100	temperature in 1/10°C
GETTEMP1	0x2	0	0x100	temperature in 1/10°C
GETTEMP2	0x3	0	0x100	temperature in 1/10°C
GETTEMP3	0x4	0	0x100	temperature in 1/10°C
GETTEMP4	0x5	0	0x100	temperature in 1/10°C
GETTEMPOFF	0x6	0	0x100	temperature in 1/10°C
GETTEMPHYS	0x8	0	0x100	temperature in 1/10°C
GETLSTAT	0x10	0	0x110	32bit number
SETLSTAT	0x11	32bit number	0x110	32bit number
GETERROR	0x20	0	0x120	32bit number
GETWIDTH	0x30	0	0x130	width in [us]
GETWIDTHMIN	0x31	0	0x130	minimum width in [us]
GETWIDTHMAX	0x32	0	0x130	maximum width in [us]
GETWIDTHSTEPSIZE	0x33	0	0x130	size of one step in [us]
SETWIDTH	0x34	width in [us]	0x130	width in [us]
GETREPRATE	0x35	0	0x130	reprate in [Hz]
GETREPRATEMIN	0x36	0	0x130	minimum reprate in [Hz]
GETREPRATEMAX	0x37	0	0x130	maximum reprate in [Hz]
GETREPRATESTEPSIZE	0x38	0	0x130	size of one step in [Hz]
SETREPRATE	0x39	reprate in [Hz]	0x130	reprate in [Hz]
GETCOUNT	0x3A	0	0x130	pulses per trigger
GETCOUNTMIN	0x3B	0	0x130	minimum number of pulses
GETCOUNTMAX	0x3C	0	0x130	maximum number of pulses
GETCOUNTSTEPSIZE	0x3D	0	0x130	size of one step
SETCOUNT	0x3E	pulses per trigger	0x130	pulses per trigger
GETFFWD	0x40	0	0x140	voltage in 1/100V
GETFFWDMIN	0x41	0	0x140	minimum voltage in 1/100V
GETFFWDMAX	0x42	0	0x140	maximum voltage in 1/100V
SETFFWD	0x43	voltage in 1/100V	0x140	voltage in 1/100V

Command	Sent Frame		Received Frame	
	Command	Parameter	Command	Parameter
GETCAP	0x50	0	0x150	voltage in 1/10V
GETCAPMIN	0x51	0	0x150	minimum voltage in 1/10V
GETCAPMAX	0x52	0	0x150	maximum voltage in 1/10V
SETCAP	0x53	voltage in 1/10V	0x150	voltage in 1/10V
GETI	0x60	0	0x160	strength of I
GETIMIN	0x60	0	0x160	minimum I value
GETIMAX	0x60	0	0x160	maximum I value
SETI	0x60	strength of I	0x160	strength of I
GETP	0x60	0	0x160	strength of P
GETPMIN	0x60	0	0x160	minimum P value
GETPMAX	0x60	0	0x160	maximum P value
SETP	0x60	strength of P	0x160	strength of P
GETCUR	0x70	0	0x170	current in [A]
GETCURMIN	0x71	0	0x170	minimum current in [A]
GETCURMAX	0x72	0	0x170	maximum current in [A]
SETCUR	0x73	current in [A]	0x170	current in [A]
GETOCUR	0x80	0	0x180	over current in [A]
GETOCURMIN	0x81	0	0x180	minimum over current in [A]
GETOCURMAX	0x82	0	0x180	maximum over current in [A]
SETOCUR	0x83	over current in [A]	0x180	over current in [A]
GETIDELAY	0x90	0	0x190	delay in 1/10%
GETIDELAYMIN	0x91	0	0x190	minimum delay in 1/10%
GETIDELAYMAX	0x92	0	0x190	maximum delay in 1/10%
SETIDELAY	0x93	delay in 1/10%	0x190	delay in 1/10%
LOADDEFAULTS	0xB0	0	0x1B0	0 (see below)
SAVEDEFAULTS	0xB1	0	0x1B0	0 (see below)
GETADCUDIODE	0xC0	0	0x1C0	output voltage in 1/10V
GETADCIDIODE	0xC1	0	0x1C0	output current in [A]
GETADCVCAP	0xC2	0	0x1C0	capacitor voltage in 1/10V
GETADC5V	0xC3	0	0x1C0	internal 5V in 1/10V
GETADC12V	0xC4	0	0x1C0	internal 12V in 1/10V
GETADCUIN	0xC5	0	0x1C0	input voltage in 1/10V

Command	Sent Frame		Received Frame	
	Command	Parameter	Command	Parameter
GETADCISOLL	0xC6	0	0x1C0	external set point current in [A]
GETADCPULSSAMPLES	0xC7	0	0x1C0	see below
GETADCPULSIDIODE	0xC8	see below	0x1C0	output current in [A]
GETADCPULSUDIODE	0xC9	see below	0x1C0	output voltage in 1/10V
GETADCPULSVCAP	0xCA	see below	0x1C0	capacitor voltage in 1/10V
GETADCPULSI	0xCB	see below	0x1C0	see below
GETADCPULSP	0xCC	see below	0x1C0	see below

Description of the Individual Commands

GETTEMP
Returns the maximum of the GETTEMP1 … GETTEMP4 commands. The value is encoded as a signed integer (16bit), measured in steps of 0.1°C.

GETTEMP1…4
Returns the measured value of the according temperature sensor. The value is encoded as a signed integer (16bit), measured in steps of 0.1°C.

GETTEMPOFF
Returns the temperature border at which the device shuts down automatically. The value is encoded as a signed integer (16bit), measured in steps of 0.1°C.

GETTEMPHYS
Returns the temperature to which the device must cool down until it can be switched on again. The value is encoded as a signed integer (16bit), measured in steps of 0.1°C.

GETLSTAT
Returns the content of the laser status register (32bit). For a detailed description of the single bits see chapter "description of the LSTAT register".

SETLSTAT
Sets the laser status register to the given value. The return value contains the acquired register content. For a detailed description of the single bits see chapter "description of the LSTAT register".

GETERROR
Returns the content of the error register (32bit). For a detailed description of the single bits see chapter "description of the ERROR register".

GETWIDTH
Returns the current pulse width of the internal pulse generator.

GETWIDTHMIN
Returns the minimum possible pulse width of the internal pulse generator. The value is measured in [us].

GETWIDTHMAX
Returns the maximum possible pulse width of the internal pulse generator. This value depends of the current repetition rate. Hence, any change in the repetition rate changes this value too. It is measured in [us].

SETWIDTH
Sets the pulse width of the internal pulse generator to the given value. It must be within the borders defined by GETWIDTHMIN and GETWIDTHMAX. The value is measured in [us].

GETREPRATE
Returns the current repetition rate of the internal pulse generator. The value is measured in [Hz].

GETREPRATEMIN
Returns the minimum possible repetition rate of the internal pulse generator. The value is measured in [Hz].

GETREPRATEMAX
Returns the maximum possible repetition rate of the internal pulse generator. This value depends of the current pulse width. Hence, any change in the pulse width changes this value too. It is measured in [Hz].

SETREPRATE
Sets the repetition rate of the internal pulse generator to the given value. It must be within the borders defined by GETREPRATEMIN and GETREPRATEMAX. The value is measured in [Hz].

GETCOUNT
Returns the number of pulses the internal pulse generator will generate as soon as it becomes enabled. This is only used if the counting mode is enabled. See chapter "trigger modes" for more information.

GETCOUNTMIN
Returns the minimal number of pulses the pulse generator can produce if counting mode is enabled.

GETCOUNTMAX
Returns the maximal number of pulses the pulse generator can produce if counting mode is enabled.

SETCOUNT
Sets the number of pulses the pulse generator will generate to the given value. It must be within the borders defined by GETCOUNTMIN and GETCOUNTMAX.

GETFFWD
Returns the actual feed forward voltage used by the current regulator. See chapter "current regulator" for more information. It is measured in steps of 0.01[V]

GETFFWDMIN
Returns the minimal feed forward voltage used by the current regulator. It is measured in steps of 0.01[V]

GETFFWDMAX
Returns the maximal feed forward voltage used by the current regulator. It is measured in steps of 0.01[V]

SETFFWD
Sets the feed forward voltage used by the current regulator to the given value. It must be within the borders defined by GETFFWDMIN and GETFFWDMAX. See chapter "current regulator" for more information. The value is measured in steps of 0.01[V]

GETCAP
Returns the actual pre charge voltage of the capacitor bank. See chapter "current regulator" for more information. It is measured in steps of 0.1[V]

GETCAPMIN
Returns the minimal pre charge voltage of the capacitor bank. It is measured in steps of 0.1[V]

GETCAPMAX
Returns the maximal pre charge voltage of the capacitor bank. It is measured in steps of 0.1[V]

SETCAP
Sets the pre charge voltage of the capacitor bank to the given value. It must be within the borders defined by GETCAPMIN and GETCAPMAX. See chapter "current regulator" for more information. The value is measured in steps of 0.1[V]

GETI
Returns the actual strength of the integral part of the current regulator. See chapter "current regulator" for more information.

GETIMIN
Returns the minimal strength of the integral part of the current regulator.

GETIMAX
Returns the maximal strength of the integral part of the current regulator.

SETI
Sets the strength of the proportional part of the current regulator to the given value. It must be within the borders defined by GETIMIN and GETIMAX. See chapter "current regulator" for more information.

GETP
Returns the actual strength of the proportional part of the current regulator. See chapter "current regulator" for more information.

GETPMIN
Returns the minimal strength of the proportional part of the current regulator.

GETPMAX
Returns the maximal strength of the proportional part of the current regulator.

SETP
Sets the strength of the proportional part of the current regulator to the given value. It must be within the borders defined by GETPMIN and GETPMAX. See chapter "current regulator" for more information.

GETCUR
Returns the actual set point current of the current regulator. See chapter "current regulator" for more information. The value is measured in [A].

GETCURMIN
Returns the minimal set point current of the current regulator. It is measured in [A].

GETCURMAX
Returns the maximal set point current of the current regulator. It is measured in [A].

SETCUR
Sets the set point current of the current regulator to the given value. It must be within the borders defined by GETCURMIN and GETCURMAX. See chapter "current regulator" for more information. The value is measured in [A].

GETOCUR
Returns the actual over current protection border. If the output current reaches this value, the output became disabled. The value is measured in [A].
Please note that this protective feature needs to be enabled.

GETOCURMIN
Returns the minimal possible value useable for over current protection. It is measured in [A].

GETOCURMAX
Returns the minimal possible value useable for over current protection. It is measured in [A].

SETOCUR
Sets the over current protection border to the given value. It must be within the borders defined by GETOCURMIN and GETOCURMAX. The value is measured in [A].

GETIDELAY
Returns the switching-on threshold of the integral part of the current regulator. If the output current reaches this value, the integral part will be enabled. The value is measured in 0.1[%] of the set point. See chapter "current regulator" for more information.

GETIDELAYMIN
Returns the minimal possible value useable as switching-on threshold. It is measured in 0.1[%].

GETIDELAYMAX
Returns the maximal possible value useable as switching-on threshold. It is measured in 0.1[%].

GETIDELAY
Sets the switching-on threshold of the integral part of the current regulator to the given value. If the output current reaches this value, the integral part will be enabled. The value is measured in 0.1[%] of the set point.
See chapter "current regulator" for more information.

LOADDEFAULTS
This command replaces all internal parameters with their default values. If the output is enabled during the execution of this command, the L_ON bit of the LSTAT register will be cleared and the output disabled. This command will fail if the CRC_DEFAULT_FAIL bit in the ERROR register I set, indicating an error within the data.
If the DEF_PWRON bit in the LSTAT register is set, the device automatically loads these values during power-up.

SAVEDEFAULTS
This command saves all internal parameters into an EEPROM for later usage. Use command LOADDEFAULTS to restore them.

GETADCUDIODE
Returns the current output voltage of the device. The value is measured in 0.1[V].

GETADCIDIODE
Returns the current output current of the device. The value is measured in [A].

GETADCVCAP
Returns the voltage of the capacitor bank. The value is measured in 0.1[V].

GETADCISOLL
Returns the external set point current. If the ISOLL_EXT bit in the LSTAT register is set, this value is used instead of the internal one. It is measured in [A].

GETADCPULSSAMPLES
Returns the number of samples taken by the LDP-QCW during the last pulse. Please see chapter "pulse measurement" for more information.

GETADCPULSIDIODE
This command takes the number of the desired sample and returns the appropriate measurement value. It is measured in [A]. If an invalid sample number is given, ILGLPARAM will be send.

GETADCPULSUDIODE
This command takes the number of the desired sample and returns the appropriate measurement value. It is measured in 0.1[V]. If an invalid sample number is given, ILGLPARAM will be send.

GETADCPULSVCAP
This command takes the number of the desired sample and returns the appropriate measurement value. It is measured in 0.1[V]. If an invalid sample number is given, ILGLPARAM will be send.

GETADCPULSI
This command takes the number of the desired sample and returns the appropriate measurement value. If an invalid sample number is given, ILGLPARAM will be send.

GETADCPULSP
This command takes the number of the desired sample and returns the appropriate measurement value. If an invalid sample number is given, ILGLPARAM will be send.

Description of the LSTAT Register

The following list contains a description of the individual LSTAT bits. These can be read with the GETLSTAT and written with SETLSTAT command.

Bit	Name	Read/Write	Meaning
0	L_ON	r/w	Enables / disables the output.
1	ISOLL_EXT	r/w	When "1", the external current set point is used
2	ENABLE	ro	Indicates the state of the ENABLE pin of the BOB connector.
3	MASTER_ENABLE	ro	Indicates the state of the MASTER_ENABLE pin of the BOB connector.
4	PULSER_OK	ro	When the bit is read "0" an error has occurred
5	DEF_PWRON	r/w	When "1" the device load its default values on power-on
6	INIT_COMPLETE	ro	When "1" the internal power-on sequence is complete
7-8	TRG_MODE	r/w	Trigger mode: 0 : external pulse input 1 : internal pulse generator 2 : external controlled 3: not used
9	TRG_COUNT	r/w	When "1" the counted mode is active
10	TRG_EDGE	r/w	When "1" the positive edge is used
11	OVERCUR_EN	r/w	Enabled / disables the over current protection
12-13	REG_MODE	r/w	Regulator mode: 0 : manual 1 : semi-automatic 2 : not used 3 : not used
14-31	Reserved	ro	Reserved

Description of the ERROR Register

The following list contains a description of the individual bits of the ERROR register. A "1" as a bit leads to a deactivation of the output current. Bits 0, 1, 7 and 17 are excluded of this directive.

The ERROR bits are cleared by disabling of the ENABLE pin.

Bit	Name	Read/Write	Meaning
0	CRC_DEVDRV_FAIL	ro	A CRC error was detected in the PLB driver. The driver cannot be used. This does not affect the device but the PLB.
1	CRC_DEFAULT_FAIL	ro	A CRC error was detected in the default values. A re-save of the values should correct this.
2	CRC_CONFIG_FAIL	ro	A CRC error was detected in the internal configuration values. Please contact your distributor.
3	reserved	ro	
4	CRC_FFWDCAL_FAIL	ro	A CRC error was detected in the internal calibration values. Please contact your distributor.
5	OCUR_DETECTED	ro	The over current protection has disabled the output.
6	TEMP_OVERSTEPPED	ro	The internal temperature was beyond safe operating limits.
7	TEMP_WARNING	ro	The internal temperature is 5°C before shutdown.
8	TEMP_HYSTERESE	ro	Device is cooling down. Temperature needs to drop below (maximum – 10°)
9	PULS_TOO_LONG	ro	The supplied trigger pulse was too long.
10	VOLTAGE_5V_FAIL	ro	Internal supply voltage error.
11	VOLTAGE_12V_FAIL	ro	Internal supply voltage error.
12	VOLTAGE_IN_FAIL	ro	The supply voltage is too low or too high
13	FAILED_TO_LOAD_DEF	ro	The loading of the default failed. Normally this is because of an pending CRC error.
14	I2C_EEPROM_FAIL	ro	Internal EEprom error. Please contact your distributor.
15	I2C_DAC_1_FAIL	ro	Internal DAC error. Please contact your distributor.
16	I2C_DAC_2_FAIL	ro	Internal DAC error. Please contact your distributor.
17	ENABLE_POWERON	ro	ENABLE and / or MASTER_ENABLE pin was high during power-on.
18-31	reserved	ro	